Plant richness and community establishment after five growing seasons in the two experimental wetland basins

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Introduction

Numerous physical, chemical and biological indicators of wetland creation success or failure can be measured in various compartments and at various spatial and temporal scales of the ecosystem (Kusler and Kentula, 1990; Kentula et al., 1992; Henry and Amoros, 1995). More than being one of the easiest factor to appreciate (Kusler and Kentula, 1990), vegetation establishment is certainly among the most important factors in the successful functioning of created wetlands since it affects many potential functions of these ecosystems (Mitsch and Gosselink, 1993). Macrophytes are responsible for a large amount of the primary production of material that fuels diverse food chains, from microbial to consumers food chains. Moreover, in sheltered areas, plants offer attractive feeding sites for both fish and birds and thus function as refuges and nurseries for selected species. Finally, the emergent vegetation filters sediments and nutrients from the watershed. For all these vital functions, the establishment of diverse and productive plant communities is a primary goal of wetland creation efforts.

Studies of plant establishment in man-made environments are of interest both from an applied and a theoretical point of view. Because succession rarely occurs in an orderly manner, it is often difficult to determine which plant communities will ultimately become established at a created wetland (Niering, 1990, Stauffer and Brooks, 1997). Moreover, there is sparse knowledge based on long-term monitoring of vegetation development in created wetlands (Reinartz and Warne, 1993; Odland, 1997).

Many conditions influence macrophyte community development both in term of spatial and temporal scale. Hydrology is certainly one of the major factors influencing macrophytes communities (Odum, 1988; Fennessy et al., 1994; Willis and Mitsch, 1995; Clevering and van Gulik, 1996; Vivian-Smith and Handel, 1996), but other factors such as method of plant introduction are also primordial (Willard and Hiller, 1990; Zedler and Weller, 1990).

The Olentangy River Wetland Research Park (ORWRP) provides a unique opportunity to monitor a wetland creation and to study the process of macrophyte establishment in created wetlands over a long period of time. Two 1-ha basins were constructed in 1993-94 and one of them (Wetland 1) was planted in May 1994 with 13 species typical of Midwestern marshes. The second basin (Wetland 2) was left as an unplanted control, allowing comparison of ecosystems development between planted and unplanted wetlands. The initial hypothesis was that *"planted and unplanted basins will be similar in function in the beginning, diverge in function during the middle years and ultimately converge in structure and function"* (Mitsch et al., 1998).

The present paper mostly reports results of vegetation investigation at the site in 1998, the fifth growing season after basin creation. These data are presented and discussed in reference with similar studies from the first two years (Weihe, 1996, Weihe and Mitsch, 1996a,b), the third year (Liptak et al., 1997) and the fourth year (Bouchard et al., 1998, Mitsch and Bouchard, 1998). To test the effect of planting/non-planting on vegetation communities, five years after the two wetlands creation, we measured plant richness, organization and cover at the basin scale (e.g., ecosystem scale, limited replication) and at a transect approach (e.g., smaller scale, replication).

Methods

Global plant diversity survey

A vegetation survey of the two basins was conducted on foot in late August 1998, all around the two basins. All plants inside the ring of Eastern cottonwood (*Populus deltoides*) have been identified to the species. For each species, global abundance was estimated using a four-tiered qualitative classification scheme (not found, present, common or abundant). Indicator status for Region 1 (Northeast) was determined for as many species as possible using the National List (Reed, 1988). Species not found in this National List was indicated as non-listed.

General map of the vegetation communities

A color aerial photograph taken in late August 1998 was used to delineate patches on the ground representing the extent of the two wetlands and the extent of characteristic assemblages of species. The picture was scanned and imported into Photoshop where the different color patterns were carefully analyzed and mapped. Field verifications were made in middle and late September in order to determine the different plant communities associated with the different patches of color. Coverage of the different communities of emergent and floating macrophytes were estimated for both wetlands.

Transect analysis along the mudflat

In each wetland, 9 transects were located in 1997 (Bouchard et al., 1998) across the mudflat gradient from the inflow to the outflow (Fig. 1). Each transect was divided into three areas corresponding to the three zones—0, 1 and 2 originally determined in the mudflat gradient (Weihe and Mitsch, 1996a). These transects were 2 m wide. When possible, transects were located parallel to the boardwalk (Fig. 2). When possible, the boardwalk was used to performed this survey in order to avoid damage to wetland vegetation, mostly in Zone 0. When the boardwalk was in the middle of the transect, we separated the transect in two smaller area located on each side of the boardwalk (Fig. 2).

In each zone of each transect, species were identified and surveyed using a cover-scale index. Because the transects did not have the same length, which could cause difficulties for future data analysis, this same vegetation survey was also made inside a one-meter square quadrat located in the middle of each zone. The vegetation was surveyed using the Braun-Blanquet cover scale: (+) a limited number of individuals, vegetation cover < 5 %; (1) plentiful number of individuals, vegetation cover < 5%, (2) vegetation cover between 5 and 25 %, (3) vegetation cover between 25 and 50 %, (4) vegetation cover between 50 and 75 %, and (5) vegetation cover > 75 % (Braun-Blanquet, 1932).

Results

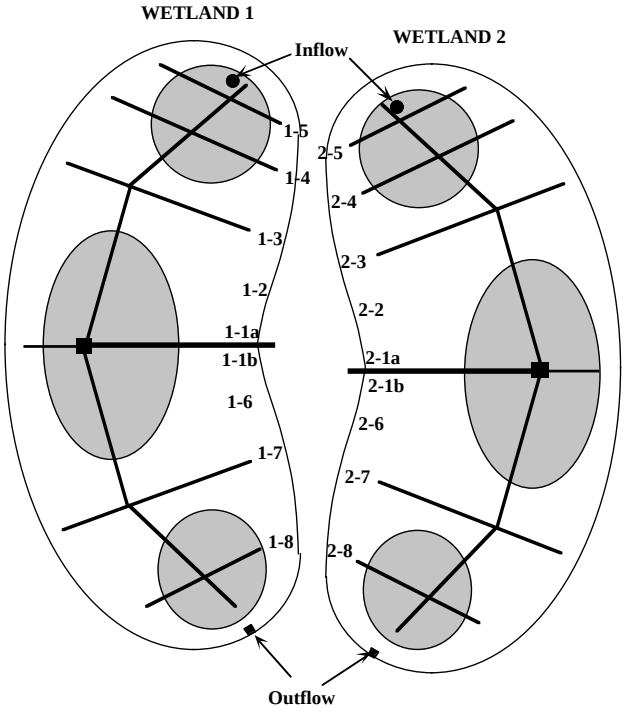

Figure 1. Map of each experimental wetland showing the location of boardwalks and transects.

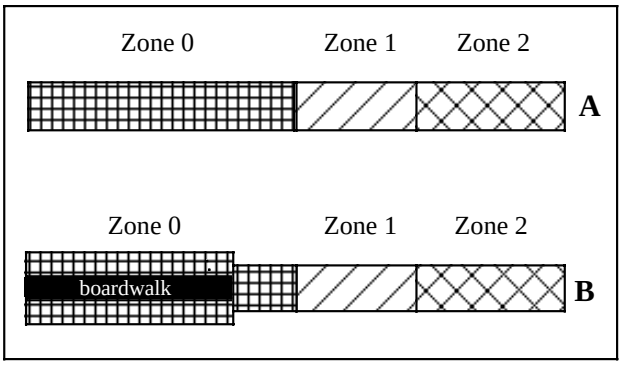

Figure 2. Schematic description of the transects located (A) away from a boadwalk or (B) along a boardwalk.

Plant diversity at the wetland scale

During the 1998 survey, a total of 99 species were identified in the two experimental basins (Table 1): 97 and 88 species were found in Wetland 1 and 2, respectively. This difference was explained mainly by a larger number of obligate species in Wetland 1 (31 species) than in Wetland 2 (22 species). In the other indicators group, there was approximately the same number of species (Table 1). The total number of species for both basins in 1994, 1995 (Weihe and Mitsch, 1996a, 1996b), 1996 (Liptak and al., 1997), 1997 (Bouchard et al., 1998) and 1998 (this study) growing seasons is summarized in Figure 3. Since the beginning of the experiment, the difference between the number of species in Wetland 1 and the number of species in Wetland 2 has remained relatively constant. Between 1994 and 1997, species richness in both wetlands increased continuously. However, there was not any increase of the number of species between the fourth (1997) and the fifth (1998) growing seasons (Figure 3).

Between 1997 and 1998, the list of obligate species remained closely the same in both basins (Fig. 4). Only *Sagittaria eurycarpum* disappeared from Wetland 2 in 1998 where it has been observed in 1997. One new FACW species (*Scirpus cyperinus*) appeared in Wetland 2 in 1998. The species named *Salix amygdaloides* during previous studies was identified as *Salix eriocephala*, and the willow previously identified as *Salix babylonica* is now called *Salix madsudana* Koidz. ("corkscrew willow" or "Peking willow") (Dr. Furlow, *pers. comm.*) in 1998.

Percent cover and macrophyte communities diversity at the wetland scale

From the aerial photograph of the wetland site, three main communities have been distinguished: 1) open water with some floating and submersed aquatics ; 2) areas colonized only by obligate emergent species (e.g., *Schoenoplectus tabernaemontani*, *Typha* spp., *Scirpus fluviatilis*, *Sparganium eurycarpum*, and *Sagittaria latifolia*); and an upper area (called edge or fringe) colonized by a very few individuals of obligate species but by all the other categories as well (Fig. 5). Total vegetation cover of the two

Table 1. Survey of vegetation in ORW wetland basins at the Olentangy River Wetland Research Park, Columbus, OH, in August 1998.

Scientific Name	Common name	Indicator	W1	W2
Acorus calamus	sweet flag	OBL	P	-
Alisma plantago-aquatica	water plantain	OBL	P	P
Asclepia incarnata	swamp milkweed	OBL	P	P
Bidens cernua	nodding bur marigold	OBL	C	C
Bidens laevis	bur marigold	OBL	P	C
Carex vulpinoidea	fox sedge	OBL	P	P
Eleocharis obtusa	blunt spikerush	OBL	P	P
Epilobium coloratum	purple-leaved willow herb	OBL	C	C
Equisetum sp.	horsetail	OBL	P	-
Juncus canadensis	Canada rush	OBL	P	C
Leersia oryzoides	rice-cut grass	OBL	C	C
Lemna minor	lesser duckweed	OBL	A	C
Leucospora multifida	narrow leaf paleseed	OBL	P	-
Lycopus americanus	American bugleweed	OBL	C	C
Mimulus ringens	Allegheny monkey flower	OBL	P	P
Nelumbo lutea	yellow lotus	OBL	P	-
Penthorum sedoides	ditch stonecrop	OBL	C	P
Polygonum hydropiperoides	mild water pepper	OBL	P	C
Potamogeton foliosus	bushy pondweed	OBL	C	C
Potamogeton natans	floating leaf pondweed	OBL	C	C
Rorippa palustris	marsh yellow cress	OBL	P	P
Sagittaria latifolia	arrowhead	OBL	C	-
Salix exigua (interior)	sandbar willow	OBL	P	P
Samolus parviflorus	water pimpernel	OBL	C	C
Saururus cernuus	lizard's tail	OBL	P	-
Schoenoplectus tabernaemontani	soft-stem bulrush	OBL	A	A
Scirpus fluviatilis	river bulrush	OBL	C	-
Sparganium eurycarpum	burreed	OBL	A	-
Spartina pectinata	prairie cordgrass	OBL	C	-
Typha angustifolia	narrow-leaved cattail	OBL	A	A
Typha latifolia	wide-leaved cattail	OBL	A	A
			31 species	22 species
			5 A	3 A
			11 C	10 C
			15 P	9 P
Aster novae-angliae	new england aster	FACW	P	P
Aster simplex	panicled aster	FACW	P	P
Bidens connata	swamp beggar ticks	FACW	P	P
Bidens frondosa	beggar ticks	FACW	A	A
Boehmeria cylindrica	false nettle	FACW	P	-
Carex tribuloides	blunt broom sedge	FACW	P	P
Cyperus esculentus	yellow nutsedge	FACW	P	P
Cyperus strigosus	umbrella sedge	FACW	C	C
Eupatorium perfoliatum	common boneset	FACW	P	-
Fraxinus pensylvanica	green ash	FACW	P	P
Impatiens capensis	spotted touch-me-not	FACW	P	P
Juncus effusus	soft rush	FACW	C	P
Juncus torreyi	Torrey's rush	FACW	P	P
Mentha arvensis	field mint	FACW	P	P
Phalaris arundinacea	reed canary grass	FACW	P	P
Polygonum lapathifolium	nodding smartweed	FACW	P	P
Polygonum pensylvanicum	pink knotweed	FACW	C	C
Polygonum persicaria	lady's thumb	FACW	P	C
Rorippa sylvestris	creeping yellow cress	FACW	P	P

Table 1. Continued

Salix alba	white willow	FACW	C	A
Salix madsudana Koidz.	corkscrew willow	FACW	P	P
Salix eriocephala	Missouri River willow	FACW	C	C
Salix nigra	black willow	FACW	C	A
Scirpus cyperinus	wool grass	FACW	-	P
Verbena hastata	blue vervain	FACW	P	P
			24 species	23 species
			1 A	3 A
			6 C	4 C
			17 P	16 P
Acer negundo	boxelder	FAC	P	P
Acer rubrum	red maple	FAC	P	P
Eupatorium serotinum	white snake root	FAC	P	P
Panicum capillare	witchgrass	FAC	P	C
Panicum virgatum	switchgrass	FAC	C	C
Populus deltoides	eastern cottonwood	FAC	A	A
Vitis vulpina	wild grape	FAC	P	P
Xanthium strumarium	cocklebur	FAC	P	C
			8 species	8 species
			1 A	1 A
			1 C	3 C
			6 P	4 P
Ambrosia artemisiifolia	common ragweed	FACU	P	P
Apocynum cannabinum	Indian hemp	FACU	C	C
Aster ericoides	heath aster	FACU	C	C
Echinochloa crusgalli	barnyard grass	FACU	P	C
Euphorbia nutans	eyebane broomspurge	FACU	P	P
Juglan cinerea	butternut	FACU	P	P
Oenothera biennis	evening primrose	FACU	P	P
Populus tremaloides	quaking aspen	FACU	P	P
Prunella vulgaris	heal all	FACU	P	C
Rumex crispus	curly dock	FACU	P	P
Solanum carolinense	horse nettle	FACU	P	P
Solidago altissima	tall goldenrod	FACU	A	A
Sorghum halepense	Johnson grass	FACU	P	P
Taraxacum officinale	common dandelion	FACU	P	P
Trifolium hybridum	alsike clover	FACU	A	A
Trifolium pratens	red clover	FACU	A	A
Verbena urticifolia	white vervain	FACU	P	P
			17 species	17 species
			3 A	3 A
			2 C	4 C
			12 P	10 P
Agrostis tenuis	colonial bent grass	NL	C	C
Amaranthus cruentus	purple amaranth	NL	P	P
Asclepia syricea	common milkweed	NL	P	P
Cirsium altissimum	tall thistle	NL	P	P
Convolvulus sepium	hedge bindweed	NL	P	P
Daucus carota	wild carrot	NL	C	C
Erigeron canadensis	horseweed	NL	P	P
Juncus dudleyi	Dudley's rush	NL	P	P
Lespedeza intermedia	wandlike bush cover	NL	-	P
Oxalis sticta	yellow wood sorrel	NL	P	P
Pastinaca sativa	wild parsnip	NL	P	P
Phaseolus polystachios	wild bean	NL	P	P
Rhus radican	poison ivy	NL	C	C
Setaria viridis	foxtail grass	NL	C	C

Table 1. Continued

Ulmus porecea	English elm	NL	P	P
Ulmus pumila	Chinese elm	NL	P	C
			15 species	16 species
			0 A	0 A
			4 C	10 C
			11 P	9 P
Sonchus oleraceus	common sow thistle	UPL	P	P
Trifolium dubium	least hop clover	UPL	P	P
			2 species	2 species
			0 A	0 A
			0 C	0 C
			2 P	2 P

P - Present, C - Common, A - Abundant. OBL = obligate wetland species (occurs 99% in wetlands), FACW = facultative wetland species (occurs 67-99% in wetlands), FAC = facultative species (occurs 34-66% in wetlands), FACU = facultative upland species (67-99% in uplands), UPL = obligate upland species (>99% in nonwetlands), NL = not listed on the National List (Region 1). + planted in W1 on May 14, 1994

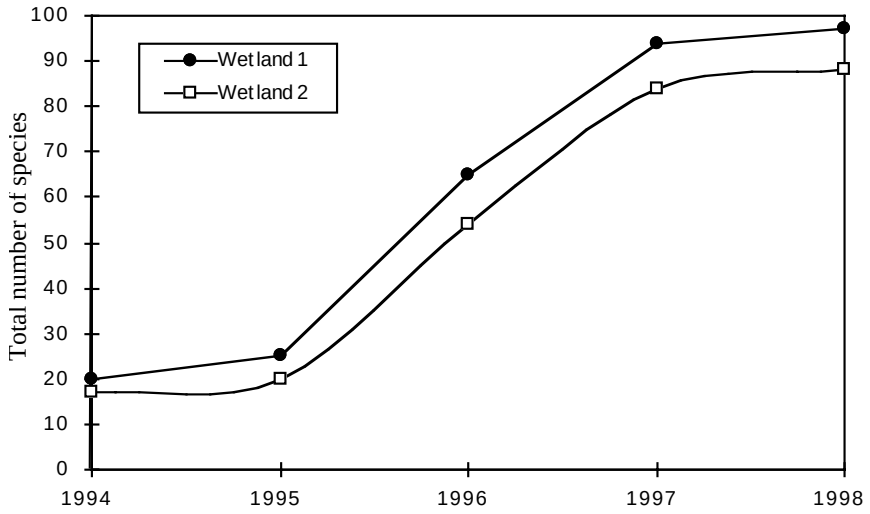

Figure 3. Number of species in each basins in 1994, 1995 (Weihe, 1996), 1996 (Liptak et al., 1997), 1997 (Bouchard et al., 1998) and 1998 (this study).

wetlands in September 1998 is illustrated in Table 2. We estimated that Wetland 1 had approximately 55 % vegetative coverage, while Wetland 2 had about 61 % vegetative coverage. Vegetation cover has increased continuously in both basins since 1994 (Fig. 6). In 1994 there was essentially no macrophyte cover. In 1995, the cover was slightly higher in Wetland 1 than in Wetland 2; the opposite pattern has been observed in 1997 and 1998.

The analysis of aerial photography has allowed us to identify six vegetation communities (Fig. 5 and Table 2). These communities have been identified according to their dominant species. In some patches, the dominant species represented almost 100% of the total coverage, whereas in others, the dominant species represented only 75% of the cover. Compared to 1997, the major change in the two basins concerned the extent of the *Typha* spp. community in Wetland 2; this community represented 21% of the cover in

Table 2. Cover (m^2) of each vegetation community in Wetland 1 (W1) and Wetland 2 (W2).

	Communities	W1	W2
Emergent	*S. tabernaemontani*	3084	1905
	Typha spp.	81	3074
	S. fluviatilis	336	-
	S. eurycarpum	979	-
	S. latifolia	-[a]	-
Open water	no dominant veg	3286	2472
	N. lutea	73	-
Edge		1063	1221
	vegetation cover	4553	4979
TOTAL AREA		8902	8672

[a] too small to be significant cover

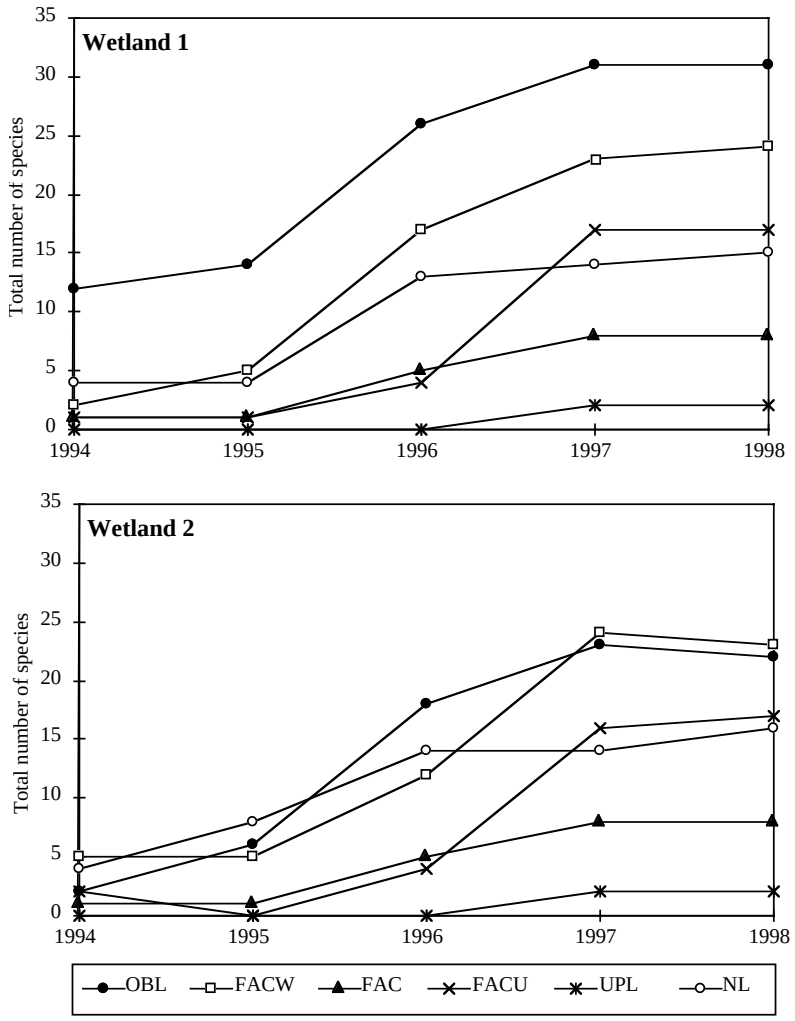

Figure 4. Number of species in each basin in 1994, 1995 (Weihe, 1996), 1996 (Liptak et al., 1997), 1997 (Bouchard et al., 1998) according to wetland indicator status (Reed, 1988).

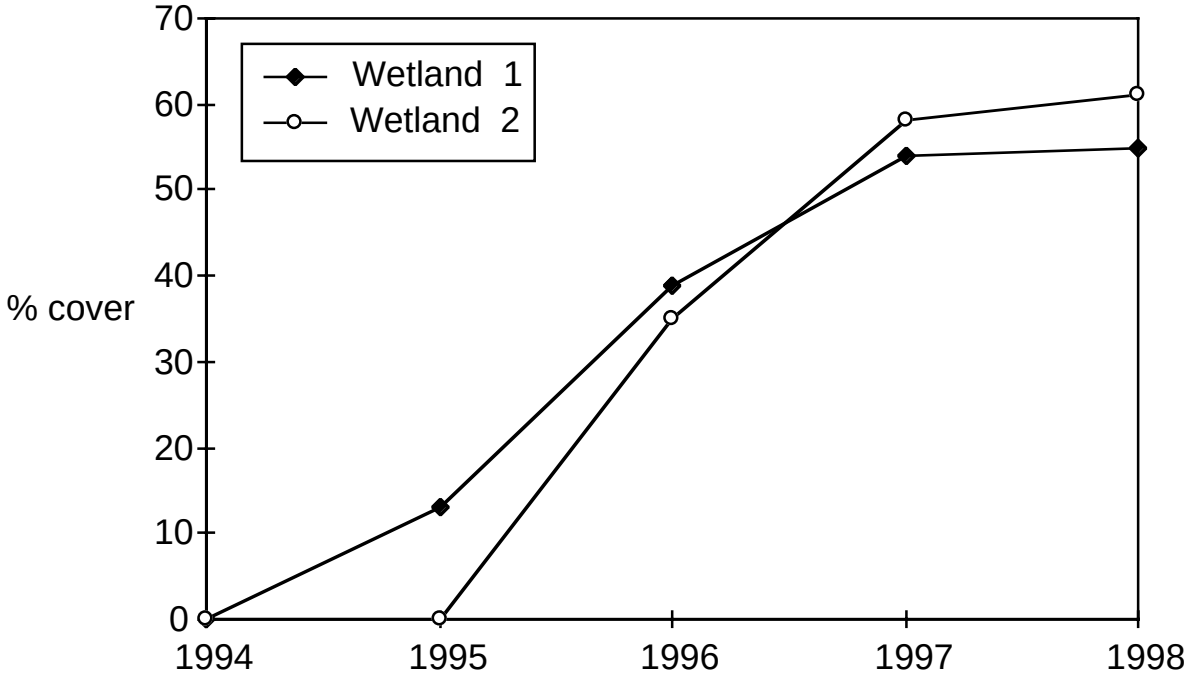

Figure 6. Development of macrophyte cover (%) in each wetland between 1994 and 1998.

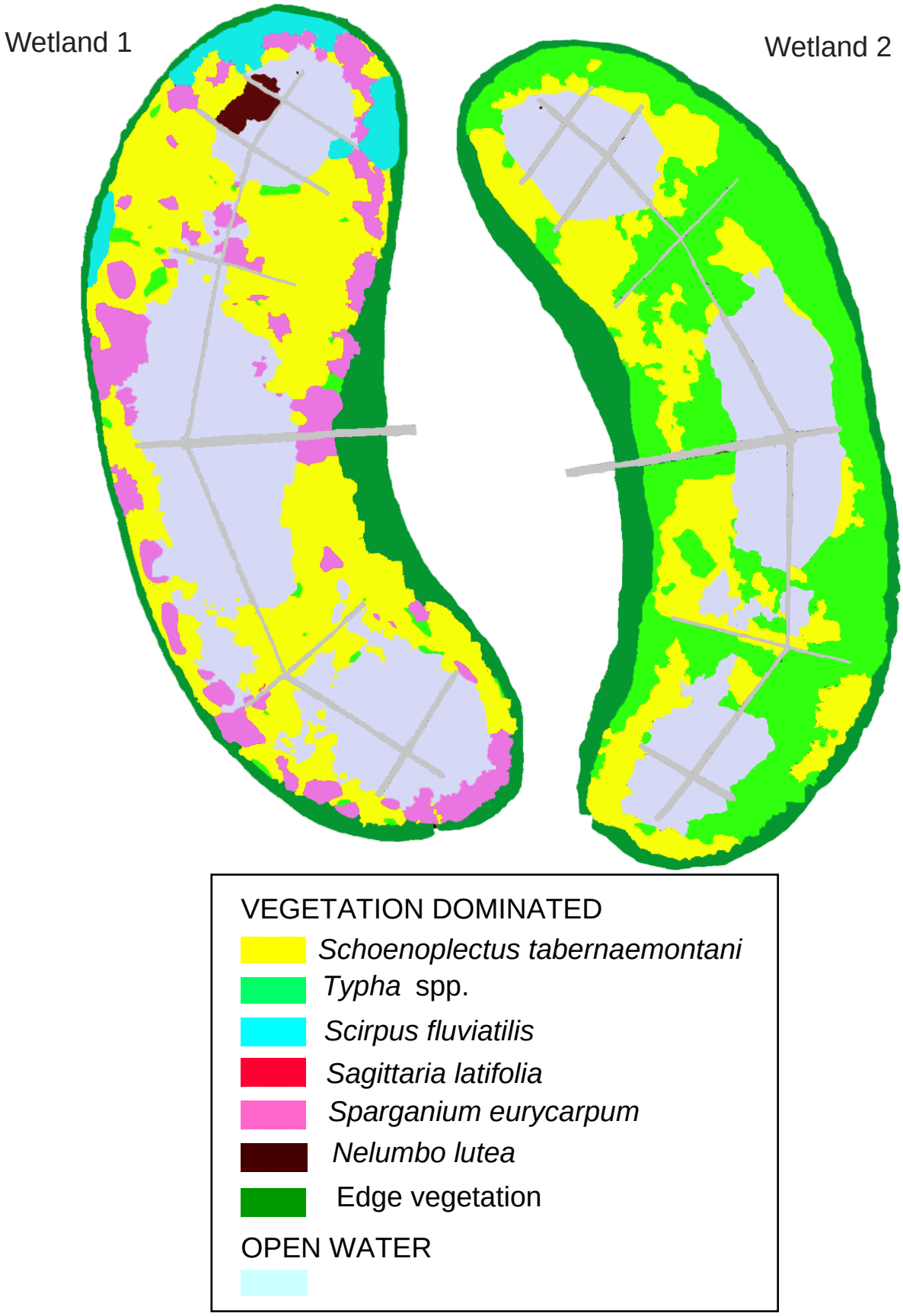

Figure 5. Vegetation map of the Olentangy River experimental wetland, September 1998, showing the principal macrophyte communities.

1997 and reached 62% in 1998. In contrast, the cover of *Typha* decreased from 7% to 2% in Wetland 1. Wetland 1 was still dominated by *Schoenoplectus tabernaemontani* with 68% of the cover, compared to 81% in 1997 (Bouchard et al., 1998). In Wetland 1, cover in the *Scirpus fluviatilis* and *Sparganium eurycarpum* communities increased in 1998 and reached 7% and 21%, respectively. In this same wetland, *Sagittaria latifolia* development was too small to be identified as an independent community. A *Potamogeton natans* community also disappeared from both wetlands, but this might be due to the low quality of the photograph. The patch of *Nelumbo lutea* in Wetland 1 near the inflow doubled between 1997 (36 m^2) and 1998 (73 m^2).

Spatial pattern of plant communities

Only the data obtained from the global investigation of each zone of each transect were used in this study. Data from the 1 m2 quadrats are presented in Appendix A.

The species richness in Wetland 1 and 2 according to each zone is presented in Figure 7. Globally species richness is higher in the shallow water zone 1 and the moist soil zone 2 than in deepwater zone 0. In contrast with 1997's result (Bouchard et al., 1998), species richness appears to be higher in zone 1 than in zone 2 and this is mostly true in Wetland 2; however these differences are not significant. The number of obligate species was significantly higher in Wetland 1 than in Wetland 2, and these species are found mostly in Zone 0.

References

Bouchard, V. and W.J. Mitsch. 1998. Plant diversity and community establishment after four growing seasons in the two experimental basins at the Olentangy River Wetland Research Park. In: W.J. Mitsch and V. Bouchard (eds.), Olentangy River Wetland Research Park at the Ohio State University: Annual Report 1997. School of Natural Resources, Columbus OH, USA, pp. 51-70.

Braun-Blanquet, J. 1932. Plant sociology: The Study of Plant Communities. Translated by G.D. Fuller and H.S. Conard. McGraw Hill Book Co., New York, NY. 430 pp.

Clevering, O. A. and W M G van Gulik. 1996. Restoration of *Scirpus lacustris* and *Scirpus maritimus* stands in a former tidal area. Aquatic Botany 55: 229-236.

Fennessy, M.S., J.K. Cronk and W.J. Mitsch. 1994. Macrophyte productivity and community development in created freshwater wetlands under experimental hydrological conditions. Ecological Engineering 3: 469-484.

Henry, C.P. and C. Amoros. 1995. Restoration ecology of riverine wetlands: I. A scientific base. Environmental Management 19: 891-902.

Kentula, M.E., R.P. Brooks, S.E. Gwin, C.C. Holland, A.D. Sherman, and J.C. Sifneo. 1992. An approach to

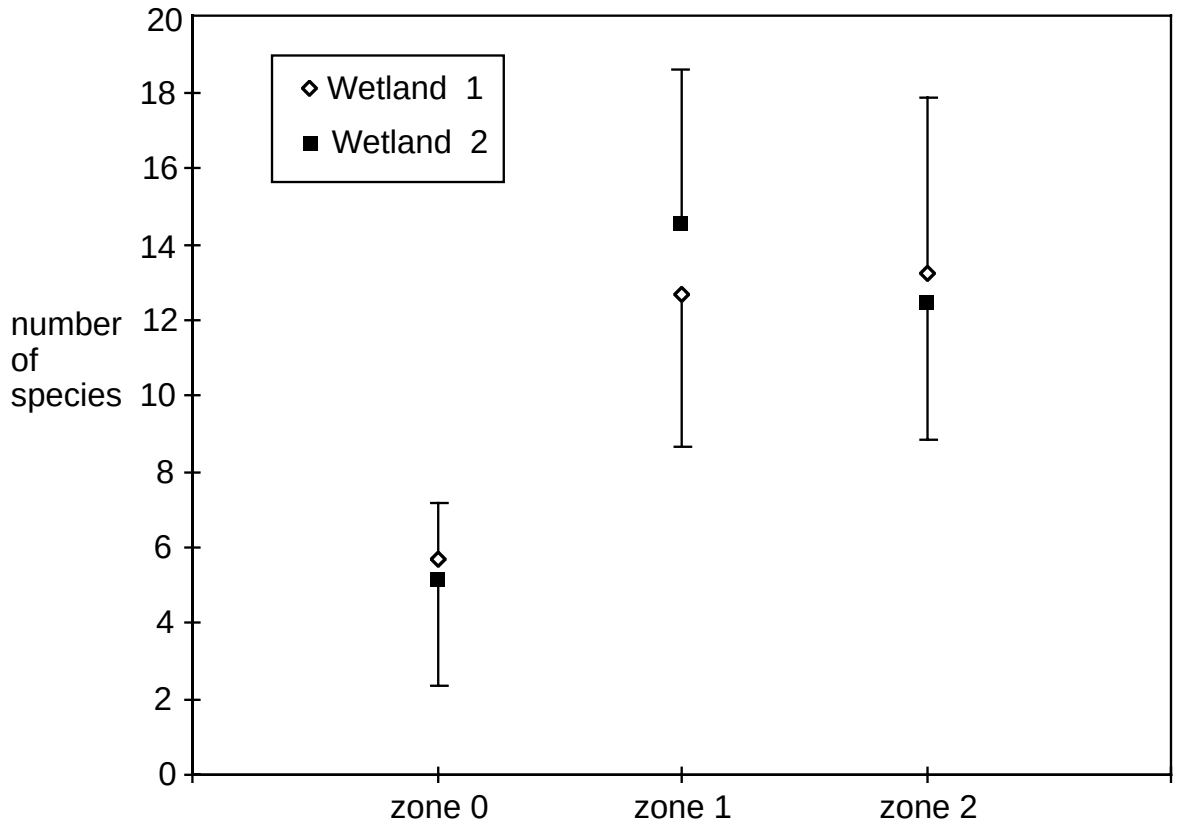

Figure 7. Species richness in each zone and each basin (n=9, bars indicate standard deviation).

improving decision making in wetland restoration and creation. U.S. Environmental Protection Agency. Island Press, Washington, DC.

Kusler, J.A. and M.E. Kentula, (eds.). 1990. Wetland Creation and Restoration: The Status of the Science. Island Press. Washington DC. 594 pp.

Liptak, M.A., L.J. Svengsouk, S.M. Johnson and W.J. Mitsch 1997. Wetland macrophyte development in the experimental wetlands at the Olentangy River Wetland Research Park during the third growing season 1996. In: Mitsch, W.J. (ed.), Olentangy River Wetland Research Park at the Ohio State University: Annual Report 1996. School of Natural Resources, Columbus OH, USA. pp. 159-176.

Mitsch, W.J. and J.G. Gosselink. 1993. Wetlands, 2nd ed. Van Nostrand Reinhold, New York, New York.

Mitsch, W.J. and V. Bouchard. 1998. Net primary productivity of macrophytes in experimental marshes. In: W.J. Mitsch and V. Bouchard (eds.), Olentangy River Wetland Research Park at the Ohio State University: Annual Report 1997. School of Natural Resources, Columbus OH, USA, pp. 71-75.

Mitsch, W.J., X. Wu, R.W. Nairn, P.E. Weihe, N. Wang, R. Deal and C.E. Boucher. 1998. Creating and restoring wetlands–an ecosystem experiment in self-design. Bioscience

Niering, W.A. 1990. Vegetation dynamics in relation to wetland creation. In; J.A. Kusler and M.E. Kentula (eds), Wetland creation and restoration: the status of the science. Island Press. Washington DC. pp. 479-486.

Odland, A. 1997. Development of vegetation in created wetlands in western Norway. Aquatic Botany 59: 45-62.

Odum, W.E. 1988. Predicting ecosystem development following creation and restoration of wetlands. In: J. Zelazny and J.S. Feierabend (eds.), Increasing our wetland resources. National Wildlife Federation Conference Proceedings, Washington, DC. pp. 67-70.

Reed, P.B. Jr. 1988. National list of plant species that occur in wetlands: Northeast (Region 1). U.S. Fish and Wildlife Service, Washington D.C., Biological Report 88 (26.1).

Reinartz, J.A. and E.L. Warne. 1993. Development of vegetation in small created wetlands in southeastern Wisconsin. Wetlands 13: 153-164.

Stauffer, A.L. and R.P. Brooks. 1997. Plant and soil responses to salvaged marsh surface and organic matter amendments at a created wetland in central Pennsylvania. Wetlands 17: 90-105.

Vivian-Smith, G. and S.N. Handel. 1996. Freshwater wetland restoration of an abandoned sand mine: seed bank recruitment dynamic and plant colonization. Wetlands 16: 185-196.

Weihe, P.E. 1996. Colonizing and introduced vegetation in created riparian wetlands: establishment during the first two growing seasons. Ph.D. dissertation, Environmental Science Graduate Program, The Ohio State University, Columbus, USA.

Weihe, P.E. and W.J. Mitsch. 1996a. Survival and growth of planted vegetation in an experimental wetland, including hydrologic effects. In: W.J. Mitsch (ed.), Olentangy River Wetland Research Park at the Ohio State University: Annual Report 1995. School of Natural Resources, Columbus OH, USA, pp. 141-156.

Weihe, P.E. and W.J. Mitsch. 1996b. Macrophyte colonization of experimental wetland during the two years following construction. In: W.J. Mitsch (ed.), Olentangy River Wetland Research Park at the Ohio State University: Annual Report 1995. School of Natural Resources, Columbus OH, USA, pp. 157-161.

Willard, D.E. and A.K. Hiller. 1990. Wetland dynamics: consideration for restored and created wetlands. In: J.A. Kusler and M.E. Kentula (eds.), Wetland creation and restoration: The status of science. Island Press, Washington, DC. pp. 459-466.

Willis, C. and W.J. Mitsch. 1995. Effects of hydrology and nutrients on seedling emergence and biomass of aquatic macrophytes from natural and artificial seed banks. Ecological Engineering 4: 65-76.

Zedler, J.B. and M.W. Weller. 1990. Overview and future directions. In: J.A. Kusler and M.E. Kentula (eds.), Wetland creation and restoration: The status of science. Island Press, Washington, DC. pp. 405-413.

Appendix A. Vegetation survey along the transects in 1998, according to the 3 zones (Zone 0, Zone 1 and Zone 2), sampling in the global and square meter quadrat (sq m Q) and according to Braun-Blaunquet (bb) and ACOE methods.

	ZONE 0				ZONE 1				ZONE 2			
	global		sq m Q		global		sq m Q		global		sq m Q	
	bb	acoe	bb	acoe	bb	acoe	bb	acoe	bb	acoe	bb	acoe
Transect 1-1a												
Acorus calamus	+	1			1	1	1	1	1	1		
Agrostis tenuis					1	1	+	1	3	3	3	3
Aster sp									+	1		
Bidens frondosa					1	1	+	1				
Carex vulpinoidea									1	1		
Convolvulus sepium									+	1		
Epilobium coloratum					1	1	1	1	1	1	+	1
Impatiens capensis					+	1			+	1		
Juncus canadensis					1	1	1	1				
Juncus effusus					3	3	3	3	+	1		
Lycopus americanus					1	1	1	1	2	2	1	1
Mimulus ringens					2	2	2	2	+	1		
Penthorum sedoides					2	2	1	1	1	1	+	1
Populus deltoides					+	1	+	1	3	3	3	3
Sagittaria latifolia	+	1										
Salix alba					+	1						
Salix nigra					1	1	1	1	+	1		
Samolus parviflorus					+	1						
Saururus cernuus					+	1						
Schoenoplectus tabernaemontani	2	2	2	2	+	1						
Setaria viridis									1	1	1	1
Sparganium eurycarpum	5	5	5	5								
Spartina pectinata	+	1			3	3	3	3	2	2	2	2
Typha sp	+	1	+	1								
Transect 1-1b												
Acer negundo					+	1						
Acorus calamus					+	1						
Agrostis tenuis									2	2	2	2
Apocynum cannabinum									+	1		
Aster sp					+	1			1	1		
Bidens frondosa					1	1	1	1	+	1		
Daucus carota									1	1	1	1
Epilobium coloratum					1	1	1	1	1	1		
Juncus effusus					1	1			1	1		
Leersia oryzoides					1	1						
Lycopus americanus					1	1			1	1	+	1
Mimulus ringens					1	1	1	1	+	1		
Oenothera biennis									+	1		
Penthorum sedoides					1	1			1	1		
Populus deltoides					1	1			4	4	4	4
Rhus radican					1	1	+	1	1	1	+	1
Sagittaria latifolia	+											
Salix eriocephala	+	1			+	1			+	1		
Salix nigra									1	1		
Schoenoplectus tabernaemontani	+	1										
Setaria viridis					1	1	1	1	2	2	2	2
Solidago sp									2	2	3	3
Sparganium eurycarpum	4	6	5	6								
Spartina pectinata	+	1			4	4	4	4	1	1	+	1
Typha sp	+	1										

Transect 1-2

Acer negundo									+	1			
Acer rubrum									+	1			
Acorus calamus					1	1	2	2					
Agrostis tenuis									2	2	2	2	
Apocynum cannabinum					+	1			1	1	+	1	
Aster sp					+	1			1	1	1	1	
Bidens frondosa	+	1			1	1	1	1					
Cirsium altissimum									+	1	+	1	
Convolvulus sepium									+	1	+	1	
Daucus carota									1	1	1	1	
Epilobium coloratum					1	1	1	1					
Juncus canadensis									1	1			
Juncus effusus					2	2	3	3	1	1	2	2	
Lycopus americanus					1	1			2	2	2	2	
Mimulus ringens					+	1							
Penthorum sedoides					2	2			1	1			
Populus deltoides					+	1	+	1	2	2	3	3	
Rhus radican					1	1	1	1	1	1	+	1	
Sagittaria latifolia	+	1	1	1									
Salix alba	+	1			2	2	1	1	1	1	1	1	
Salix eriocephala									1	1	1	1	
Salix nigra									2	2	+	1	
Schoenoplectus tabernaemontani	4	4	2	2									
Solidago sp									2	2	3	3	
Sparganium eurycarpum	4	4	4	4	2	2	2	2					
Spartina pectinata					1	1	1	1	3	3	2	2	
Trifolium hybridum									1	1	1	1	

Transect 1-3

Acorus calamus					1	1	2	2	+	1			
Agrostis tenuis									3	3	2	2	
Alisma plantago-aquatica	+	1	+	1									
Apocynum cannabinum									1	1	+	1	
Aster sp					+	1			2	2	2	2	
Bidens frondosa	+	1			1	1	1	1					
Echinochloa crusgalli	+	1											
Lemna minor	2	2	1	1									
Lycopus americanus					1	1	2	2					
Penthorum sedoides					1	1	1	1					
Populus deltoides					1	1	+	1	3	3	3	3	
Rhus radican					1	1							
Sagittaria latifolia	+	1	1	1	1	1							
Salix alba					2	2	1	1	2	2	2	2	
Salix nigra					1	1	1	1	2	2	3	3	
Schoenoplectus tabernaemontani	4	4	4	4									
Setaria viridis					1	1			1	1			
Sparganium eurycarpum	3	3	2	2	1	1							
Typha sp	4	4	4	4	1	1	+	1					

Transect 1-4

Acorus calamus					2	2	3	3					
Agrostis tenuis									2	2	2	2	
Apocynum cannabinum									+	1			
Aster sp									3	3	3	3	
Bidens connata									+	1			
Bidens frondosa					+	1	+	1	+	1			
Boehmeria cylindrica					+	1			1	1			
Daucus carota									2	2	2	2	
Epilobium coloratum					+	1			1	1			
Equisetum sp.					+	1							
Impatiens capensis					+	1							
Juncus dudleyi					+	1							

Juncus effusus					1	1	+	1	1	1		
Leersia oryzoides					1	1	+	1				
Lemna minor	2	2	2	2								
Oxalis sticta									+	1	+	1
Polygonum pensylvanicum					+	1						
Populus deltoides									2	2	2	2
Rhus radican									+	1	1	1
Sagittaria latifolia	+	1										
Schoenoplectus tabernaemontani	4	4	3	3								
Setaria viridis									2	2	2	2
Solidago sp									3	3	2	2
Sparganium eurycarpum	4	4	5	6	3	3	1	1				
Spartina pectinata					1	1						

Transect 1-5

Apocynum cannabinum					2	2	1	1	1	1		
Aster sp					+	1			2	2	2	2
Bidens frondosa	+				2	2	3	3				
Boehmeria cylindrica					1	1						
Daucus carota									2	2	1	1
Juncus effusus									+			
Leersia oryzoides					1	1						
Lemna minor	+	1										
Populus deltoides					+				2		2	
Rhus radican									1	1		
Sagittaria latifolia	1	1			+							
Schoenoplectus tabernaemontani	2	2	3	3	2	2	1	1				
Scirpus fluviatilis	3	3	3	3								
Solidago sp					1				2	2	2	2
Sparganium eurycarpum	2	2	1	1	+	1						
Vitis vulpina									+	1		

Transect 1-6

Acorus calamus					+	1						
Alisma plantago-aquatica	+	1			+	1						
Apocynum cannabinum									1	1		
Aster sp									1	1		
Bidens cernua					+	1						
Bidens connata					+	1						
Bidens laevis					+	1						
Carex vulpinoidea					+	1						
Cirsium altissimum									1	1		
Daucus carota									1	1		
Juncus canadensis									2	2		
Juncus effusus					1	1						
Leersia oryzoides					+	1						
Lemna minor	+	1										
Lycopus americanus									1	1		
Penthorum sedoides					+	1						
Populus deltoides					+	1						
Sagittaria latifolia	+	1										
Salix alba					+	1						
Salix nigra					+	1	+					
Samolus parviflorus					1	1	+	1				
Schoenoplectus tabernaemontani	4	4	4	4								
Solidago sp									3	3		
Sparganium eurycarpum	1	1	1	1								
Spartina pectinata					5	5	5	5	1	1		
Typha sp	3	3	3	3								

Transect 1-7

Acorus calamus					+	1			+	1		
Agrostis tenuis									2	2	1	1
Aster sp									1	1	1	1

Bidens frondosa					+	1	1	1				
Cyperus esculentus					+	1	+	1	+	1	1	1
Daucus carota									1	1		
Epilobium coloratum									+	1		
Juncus canadensis					+	1			2	2	3	3
Juncus dudleyi					2	2	2	2	+	1		
Juncus effusus					3	3	2	2	1	1		
Lemna minor	1	1	1	1								
Lycopus americanus					2	2	2	2	1	1		
Mimulus ringens					+	1						
Penthorum sedoides					2	2	2	2				
Populus deltoides					+	1	+	1	3	3	3	3
Sagittaria latifolia	1	1	1	1								
Salix alba					2	2	1	1	1	1	+	1
Salix nigra					2	2	2	2	3	3	2	2
Samolus parviflorus					2	2	1	1				
Schoenoplectus tabernaemontani	4	4	4	4	1	1						
Setaria viridis									2	2	1	1
Solidago sp					+	1			3	3	3	3
Sparganium eurycarpum	+	1	+	1								
Spartina pectinata					1	1			2	2		
Typha sp	3	3	4	4								

Transect 1-8

Agrostis tenuis									3	3	3	3
Amaranthus cruentus									+	1		
Aster sp.									1	1	+	1
Bidens cernua	+	1										
Bidens connata	+	1										
Bidens frondosa					1	1	+	1				
Daucus carota									1	1		
Epilobium coloratum									+	1		
Juncus effusus					1	1	1	1	+	1		
Lemna minor	+	1	+	1								
Lycopus americanus					1	1	2	2	1	1	+	1
Populus deltoides									3	3	3	3
Rumex crispus					+	1						
Sagittaria latifolia	+	1			1	1						
Salix alba					1	1	1	1	3	3	3	3
Salix nigra					1	1			2	2	3	3
Schoenoplectus tabernaemontani	3	3	3	3	1	1						
Scirpus fluviatilis	1	1	+	1								
Solidago sp									2	2	1	1
Sparganium eurycarpum	3	3	4	4	2	2	3	3				
Trifolium pratens									1	1	1	1
Typha sp	2	2	2	2	2	2	1	1	1	1	+	1

Transect 2-1a

Acer negundo									+	1		
Agrostis tenuis					+	1	+	1				
Aster sp.					+	1	+	1	3	3	3	3
Bidens cernua					1	1						
Bidens frondosa					1	1	+	1				
Daucus carota									1	1		
Echinochloa crusgalli					+	1						
Erigeron canadensis									1	1		
Juncus effusus									+	1		
Lemna minor	1	1	+	1								
Lycopus americanus									+			
Mimulus ringens					+	1	1	1				
Polygonum hydropiperoides					1	1			+	1		
Polygonum pensylvanicum					1	1						
Populus deltoides					2	2	2	2	1	1		

Rhus radican									+	1		
Salix eriocephala					+	1						
Salix nigra					4	4	4	4				
Schoenoplectus tabernaemontani	2	2	2	2								
Solidago sp					+	1			3	3	4	4
Trifolium pratens									1	1	1	1
Typha sp	4	4	4	4								
Vitis vulpina									+	1		
Xanthium strumarium					+	1						
Transect 2-1b												
Acer negundo					1	1						
Agrostis tenuis									2	2	2	2
Aster sp.					1	1						
Bidens cernua	+	1			1	1	+	1				
Bidens connata					+	1						
Bidens frondosa					1	1	+	1				
Daucus carota									+	1		
Echinochloa crusgalli					+	1						
Epilobium coloratum					+	1						
Leersia oryzoides					+	1						
Lemna minor	+	1										
Lycopus americanus					+	1			+	1		
Mimulus ringens					1	1	+	1				
Oenothera biennis									+	1		
Penthorum sedoides	+	1			1	1	+	1				
Polygonum hydropiperoides					+	1						
Polygonum pensylvanicum					+	1						
Populus deltoides					2	2	3	3	1	1	1	1
Salix alba					1	1	2	2	+	1		
Salix nigra					1	1			+	1	1	1
Schoenoplectus tabernaemontani	2	2	2	2	+	1						
Setaria viridis									1	1	1	1
Solanum carolinense									+	1		
Solidago sp					+	1			3	3	3	3
Taraxacum officinale									+	1		
Trifolium dubium									+	1	1	1
Trifolium hybridum									1	1	+	1
Trifolium pratens					+	1			+	1		
Typha sp	5	5	5	5	1	1	+	1	+	1		
Verbena hastata					+	1						
Xanthium strumarium					1	1	2	2				
Transect 2-2												
Acer negundo									+	1		
Agrostis tenuis									1	1	1	1
Ambrosia artemisiifolia									+	1		
Aster sp.					1	1	1	1	2	2	2	2
Bidens connata					2	2	+	1				
Bidens frondosa					2	2	1	1				
Cirsium altissimum									+	1		
Convolvulus sepium									1	1		
Daucus carota									2	2	2	2
Epilobium coloratum					+	1						
Erigeron canadensis					+	1			+	1		
Lemna minor	+	1										
Lycopus americanus					3	3	2	2	1	1		
Polygonum persicaria					+	1						
Populus deltoides					3	3	2	2	2	2	1	1
Salix alba	1	1			2	2	2	2				
Salix eriocephala	1	1			2	2	3	3				
Salix nigra					2	2	2	2				
Schoenoplectus tabernaemontani	3	3	2	2								

Setaria viridis									1	1	+	1
Solanum carolinense									+	1		
Solidago sp					1	1	1	1	3	3	3	3
Trifolium dubium									+	1		
Trifolium pratens									1	1	1	1
Typha sp	4	4	4	4	+	1						
Xanthium strumarium					1	1						
Transect 2-3												
Agrostis tenuis					+	1			1	1	1	1
Apocynum cannabinum					+	1			1	1	+	1
Aster sp.									2	2	2	2
Bidens cernua	+	1			2	2	2	2				
Bidens connata					1	1						
Bidens frondosa	+	1			2	2	2	2				
Bidens laevis	+	1			1	1						
Eleocharis obtusa	+	1			+	1						
Epilobium coloratum					+	1						
Lemna minor	+	1	+	1								
Lycopus americanus	+	1			4	4	4	4				
Mimulus ringens	+	1			+	1						
Oxalis sticta									+	1		
Panicum virgatum									1	1	1	1
Polygonum lapathifolium									+	1		
Polygonum pensylvanicum					+							
Populus deltoides					2	2	2	2	1	1		
Rumex crispus					+	1						
Salix alba	+	1			1	1			1	1		
Salix eriocephala	+	1							2	2	1	1
Salix nigra									+	1		
Schoenoplectus tabernaemontani	2	2	3	3								
Setaria viridis					+	1						
Solanum carolinense									2	2	1	1
Solidago sp									3	3	3	3
Trifolium pratens					+	1						
Typha sp	4	4	4	4								
Xanthium strumarium	+	1							+	1	1	1
Transect 2-4												
Aster sp.					2	2	+	1	1	1	1	1
Bidens frondosa					2	2	3	3				
Bidens laevis					2	2	1	1				
Lemna minor	+	1	+	1								
Lycopus americanus					2	2	3	3				
Mimulus ringens					+	1						
Populus deltoides					2	2	2	2	2	2	1	1
Prunella vulgaris									4	4	4	4
Salix nigra					+	1						
Schoenoplectus tabernaemontani	4	4	4	4	2	2	1	1				
Solanum carolinense					+	1			+	1		
Solidago sp					+	1			1	1		
Trifolium pratens									1	1		
Typha sp	3	3	4	4	+	1						
Verbena hastata									1	1		
Transect 2-5												
Acer negundo									+	1		
Agrostis tenuis									+	1	+	1
Aster sp.					+	1			1	1	2	2
Bidens cernua					1	1						
Bidens frondosa	+	1	1	1	1	1	1	1				
Bidens laevis					4	4	4	4				
Cirsium altissimum									+	1		
Convolvulus sepium									+	1		

Cyperus strigosus					+	1			+	1		
Daucus carota									2	2	+	1
Epilobium coloratum									+	1		
Juncus effusus									1	1	1	1
Lemna minor	+	1	+	1								
Lespedeza intermedia									3	3	3	3
Lycopus americanus					2	2	2	2	+	1	1	1
Populus deltoides					2	2	1	1	1	1		
Prunella vulgaris									2	2	2	2
Salix alba					3	3	2	2				
Salix nigra									+	1		
Schoenoplectus tabernaemontani	4	4	5	5	+	1	+	1				
Solidago sp									3	3	3	3
Taraxacum officinale									+	1		
Trifolium hybridum									3	3	2	2
Typha sp	3	3	2	2	+	1						
Ulmus porecea									+	1		

Transect 2-6

Agrostis tenuis									1	1	1	1
Apocynum cannabinum					+	1			+	1		
Aster sp.					+	1	1	1	2	2	2	2
Bidens cernua					1	1	+	1				
Bidens frondosa					2	2	1	1				
Carex vulpinoidea					1	1	1	1				
Cyperus strigosus					+	1			+	1		
Epilobium coloratum					2	2	2	2				
Juncus effusus									+	1	+	1
Lemna minor	1	1	1	1								
Lycopus americanus					2	2	2	2	+	1		
Oxalis sticta									+	1	+	1
Penthorum sedoides					+	1						
Populus deltoides					2	2	2	2	1	1	1	1
Salix alba	+	1			+	1	1	1				
Salix nigra					3	3	3	3				
Schoenoplectus tabernaemontani	4	4	4	4								
Setaria viridis					+	1	1	1				
Solidago sp									2	2	1	1
Taraxacum officinale									+	1		
Trifolium hybridum									1	1	1	1
Trifolium pratens									1	1	1	1
Typha sp	4	4	4	4	+	1						

Transect 2-7

Agrostis tenuis									+	1		
Aster sp.									2	2	2	2
Bidens frondosa					2	2	1	1				
Carex vulpinoidea					+	1						
Cyperus strigosus					+	1						
Daucus carota									2	2	2	2
Echinochloa crusgalli									+	1		
Eleocharis obtusa	+	1			+	1						
Eupatorium serotinum					+	1						
Juncus dudleyi					2	2	1	1				
Juncus effusus					1	1	+	1	1	1		
Lemna minor	1	1	1	1								
Mimulus ringens					+	1	1	1				
Oxalis sticta									+	1	+	1
Polygonum lapathifolium					+	1	1	1				
Polygonum pensylvanicum					+	1	1	1				
Populus deltoides					1	1	1	1	2	2	2	2
Salix alba	+	1			2	2	2	2				
Salix eriocephala					2	2	1	1				

Salix exigua (interior)					+	1						
Salix babylonica var.tartarica					1	1	+	1				
Salix nigra	+	1			2	2	2	2	+	1		
Schoenoplectus tabernaemontani	4	4	4	4								
Solidago sp									2	2	2	2
Sonchus oleraceus									+	1		
Trifolium dubium									+	1		
Trifolium pratens					+	1	+	1	1	1	1	1
Typha sp	4	4	4	4	+	1						
Vitis vulpina									+	1		
Xanthium strumarium					+	1						
Agrostis tenuis					+	1	+	1	3	3	3	3
Aster sp.					+	1						
Cyperus strigosus					+	1			1	1	+	1
Eleocharis obtusa					2	2	2	2				
Epilobium coloratum					1	1	1	1				
Lemna minor	+	1										
Lycopus americanus					1	1	+	1				
Mentha arvensis					+	1						
Mimulus ringens					1	1	1	1				
Populus deltoides					3	3	3	3	2	2	1	1
Salix alba	+	1			4	4	4	4	1	1		
Salix eriocephala					2	2	1	1				
Salix nigra					2	2	1	1	1	1	+	1
Schoenoplectus tabernaemontani	4	4	3	3								
Solidago sp									2	2	3	3
Trifolium pratens									2	2	2	2
Typha sp	4	4	5	6	+	1						